

POLLEN FLORA OF PAKISTAN-LI -CARYOPHYLLACEAE

ANJUM PERVEEN AND MUHAMMAD QAISER

*Department of Botany, University of Karachi,
Karachi - 75270, Pakistan*

Abstract

Pollen morphology of 74 species belonging to 23 genera of the family Caryophyllaceae from Pakistan has been examined by light and scanning electron microscope. Pollen grains are usually radially symmetrical, apolar rarely isopolar, pantoporate rarely 3-10 colpate, spheroidal to prolate-spheroidal to sub-prolate occasionally prolate. Sexine thicker or thinner than nexine. Tectum spinulose-punctate or scabrate-punctate often reticulate or reticulate-scabrate. On the basis of apertural type three distinct pollen types viz., *Silene indica*-type, *Spergula arvensis*-type and *Stellaria media*-type are recognized.

Introduction

Caryophyllaceae is a family of about 87 genera and 2300 species (Mabberley, 1987) occurring mainly in north temperate or warm temperate regions. In Pakistan it is represented by 26 genera and 110 species (Ghazanfar & Nasir, 1986). Plants are herbs or rarely subshrubs, leaves are simple, nearly always opposite and decussate, estipulate or sometimes with scarious stipules, flowers are actinomorphic and mostly bisexual rarely absent, stamens are in one or two whorls, gynoecium consists of a single compound pistil of 2-5 carpels, usually with an equal number of styles and superior ovary, fruit mostly capsule. Family includes several ornamental plants like *Arenaria* (sandwort), *Cerastium* (mouse-ear), *Stellaria* (chick weed), *Silene* (catch fly), *Dianthus* (carnation) and *Gypsophila* (baby breath).

Pollen morphology of the family Caryophyllaceae has been examined by various workers such as, Cranwell (1962), Nair (1962), Erdtman (1952), Dimbleby (1974) Kuprianova & Alyoshina (1978), Ghanzafar (1984) and Bittrich (1994). Chand (1963) studied pollen morphology of some Scandinavian Caryophyllaceae. Nowicke (1976) examined pollen morphology of the family Caryophyllaceae while conductivity of palynological studies of the order Centrospermae. Moore & Webb (1978) also examined pollen morphology of few species of the family Caryophyllaceae. Pollen of *Arenaria* L., and *Stellaria* L., species from Argentine have been examined by Volponi (1987). However, the most comprehensive study on pollen morphology of the family Caryophyllaceae is that of Punt & Hoen (1995). There are no reports on pollen morphology of the family Caryophyllaceae from Pakistan. Present investigations are based on the pollen morphology of 74 species representing 23 genera of the family Caryophyllaceae by light and scanning electron microscope.

Materials and Methods

Pollen samples were obtained from Karachi University Herbarium (KUH) or collected from the field. The list of voucher specimens is deposited in KUH. The pollen grains were prepared for light (LM) and scanning microscopy (SEM) by the standard

methods described by Erdtman (1952). For light microscopy, the pollen grains were mounted in unstained glycerin jelly and observations were made with a Nikon Type-2 microscope, under (E40, 0.65) and oil immersion (E100, 1.25), using 10x eye piece. For SEM studies, pollen grains suspended in a drop of water were directly transferred with a fine pipette to a metallic stub using double sided cello tape and coated with gold in a sputtering chamber (Ion-sputter JFC-1100). Coating was restricted to 150 Å. The S.E.M examination was carried out on a Jeol microscope JSM-2. The measurements are based on 15-20 readings from each specimen. Pollen diameter, polar axis (P) and equatorial diameter (E), aperture size, apocolpium, mesocolpium and exine thickness were measured (Tables 1-3).

The terminology used is in accordance with Erdtman (1952), Kremp (1965), Faegri & Iversen (1964) and Walker & Doyle (1975).

General pollen characters of the family Caryophyllaceae

Pollen grains are usually radially symmetrical, apolar rarely isopolar, pantoporate rarely 3-10 colpate spheroidal or prolate-spheroidal-sub-prolate to rarely prolate, Sexine thicker or thinner than nexine. Tectum spinulose-punctate or scabrate-punctate often reticulate or reticulate-scabrate. On the basis of apertural type three distinct pollen types are recognized viz., *Silene indica*-type, *Spergula arvensis*-type and *Stellaria media*-type.

Key to the pollen types

- + Pollen grains colpate *Spergula arvensis*-type
- Pollen grains porate 2

- + Tectum reticulate *Silene indica*-type
- Tectum spinulose-punctate rarely scabrate-punctate *Stellaria media*-type

Pollen type: *Silene indica* - type (Fig. 1A & D)

Pollen class: Porate

P/E ratio: 1.00

Shape: Spheroidal

Apertures: Pore more or less circular, operculate, annulate

Exine: Sexine thicker than nexine.

Ornamentation: Reticulate or reticulate – scabrate.

Measurements: Size: Length = (32.5-) 35.12 ± 0.78 (-37.5) µm and breadth (35.1) 37 ± 0.82 (40) µm, pore (7.5-) 10.11 ± 0.42 (12.5) µm in diameter. Exine 2.5 µm thick, sexine thicker than nexine. Tectum reticulate or reticulate-scabrate.

Species included: *Cucubalus baccifer* L., *Silene gonosperma* (Rupr.) Bocquet, *S. indica* Roxb.ex Otth, *S. brahuica* Boiss.

Key to the species

- + Tectum reticulate-scabrate Group-I (*Cucubalus baccifer*, *Silene brahuica*)
- Tectum simply reticulate Group-II (*Silene gonosperma*, *S. indica*)

Table 1. General pollen characters of species included in pollen type *Silene indica*.

Taxa	Pollen diameter	Pore diameter μm	Operculum	Exine in μm	Tectum
<i>Cucubalus baccifer</i> L.	35.0 (38.21 \pm 0.36) 40.0	3.75 (4.68 \pm 0.12) 5.5	Sp	2.5 (3.86 \pm 0.14) 4.50	Rt+Scab
<i>Silene gonosperma</i> (Rupr.) Bocquet	37.10 (41.85 \pm 0.70) 45.0	5.10 (5.50 \pm 0.15) 6.25	Sp	2.75 (3.60 \pm 0.15) 4.25	Rt.
<i>S. indica</i> Roxb. ex Othl.	37.50 (41.50 \pm 0.58) 45.0	4.25 (4.91 \pm 0.06) 5.25	Sp	2.50 (3.56 \pm 0.12) 4.25	Rt.
<i>S. brahuitica</i> Boiss.	32.50 (34.58 \pm 0.28) 46.50	4.0 (5.29 \pm 0.25) 6.75	sp	2.50 (3.0 \pm 0.13) 4.1	Rt+Scab

Table 2. General pollen characters of species included in pollen type *Spergula arvensis*.

Taxa	Shape	Polar axis size (P)	Breath in μm	Colpi in μm	Mesocolpium in μm	Apocolpium in μm	Exine μm thick	Tectum
<i>Spergula fallax</i> (Lowe) E & L. Kreuze	Sub-Pr	21.25 (23.6 \pm 0.8) 25.0	17.75 (19.1 \pm 0.4) 20.0	15.0 (18.2 \pm 1.08) 25.0	15.0 (16.6 \pm 0.5) 18.7	2.5 (3.2 \pm 0.30) 3.70	2.0 (2.5 \pm 0.04) 2.5	Scab-Punct
<i>S. arvensis</i> L.	Pr+Sp	22.5 (24.35 \pm 0.83) 27.5	22.5 (24.3 \pm 0.83) 27.5	12.5 (14.16 \pm 0.52) 15.0	12.5 (15.3 \pm 1.08) 17.5	2.5 (2.75 \pm 0.25) 3.10	1.75 (1.9 \pm 0.05) 2.0	Sp-Punct
<i>Spergularia diandra</i> (Guss) Heldr. & Sartl	Sp	c. 17.5	-	12.5 (12.9 \pm 0.42) 13.75	13.75 (14.37 \pm 0.62) 15.0	2.5	1.1 (1.33 \pm 0.16) 1.5	Sp-Punct
<i>S. marina</i> (L.) Griseb.	Pr+Sp	21.25 (22.8 \pm 52.0) 25.0	18.75 (22.5 \pm 0.65) 23.75	12.5 (14.6 \pm 0.3) 16.23	12.5 (14.79 \pm 0.5) 16.2	2.5 (3.43 \pm 0.3) 3.75	1.75 (1.9 \pm 0.02) 2.1	Scab+Sp
<i>S. media</i> (L.) Persl	Pr+Sp	20.0 (22.03 \pm 0.26) 25.1	17.5 (20.87 \pm 0.3) 23.75	15.0 (15.9 \pm 0.22) 17.5	12.5 (15.7 \pm 0.27) 17.5	12.5 (2.5 \pm 0.2) 3.75	1.75 (2.0 \pm 0.04) 2.25	Sp-Punct
<i>Polycarpa corymbosa</i> (L.) Lam.	Pr+Sp	14.5 (16.16 \pm 0.37) 18.0	13.0 (15.4 \pm 0.4) 17.5	13.0 (15.45 \pm 0.4) 17.5	10.0 (11.14 \pm 0.4) 12.5	1.25 (2.25 \pm 0.25) 2.1	1.5 (1.72 \pm 0.06) 2.1	Scab-Punct
<i>P. spicata</i> Wight Am	Pr+Sp	14.8 (16.8 \pm 0.31) 18.0	13.0 (15.45 \pm 0.4) 17.5	10.0 (11.14 \pm 0.4) 12.5	10.0 (11.25 \pm 0.58) 12.5	10.0 (11.25 \pm 0.56) 12.5	1.25 (2.25 \pm 0.25) 2.5	Scab-Punct
<i>Telephium imperati</i> L.	Pr	23.5 (24.89 \pm 0.5) 27.5	15.0 (17.25 \pm 0.75) 20.0	17.5 (20.71 \pm 0.7) 22.5	-	-	1.1 (1.14 \pm 0.09) 1.5	Punct

Abbreviations: Pr+Sp = Prolate-Spheroidal, Sub-Pr = Subprolate, Pr = Prolate, Sp = Spinulose, Sp-Punct = Spinulose punctate, Rt = Reticulate, Scab = Scabrate, Punct = Punctate

Table 3. General pollen characters of species included in pollen type *Stellantia indica*.

Taxa	Pollen diameter μm	Pore diameter μm	Operculum	Exine in μm	Tectum
<i>Arenaria griffithii</i> Boiss.	24.0 (27.15 \pm 0.37) 32.5	2.7.5 (4.05 \pm 0.14) 5.0	Sp	2.0 (2.52 \pm 0.03) 3.0	Sp-Punct
<i>A. leptoclados</i> (Reichb.) Guss.	22.5 (24.30 \pm 0.20) 27.5	3.0 (3.00 \pm 0.10) 5.0	Sp	2.25 (2.42 \pm 0.02) 2.5	Sp-Punct
<i>A. neelgherrensis</i> Wight & Arn.	25.0 (26.5 \pm 0.35) 32.5	3.0 (3.58 \pm 0.12) 4.7.5	sp	2.25 (2.47 \pm 0.01) 2.5	Sp-Punct
<i>A. orbiculata</i> Royle ex Edgew.	22.5 (23.9 \pm 0.27) 25.7	3.0 (3.36 \pm 0.13) 4.5	Sp	1.75 (2.23 \pm 0.056) 2.5	Sp-Punct
<i>Acanthophyllum sordidum</i> Bunge ex Boiss.	30.0 (34.38 \pm 0.45) 38.25	2.50 (3.21 \pm 0.10) 4.50	Sp	2.25 (2.95 \pm 0.12) 3.75	Sp-Punctate
<i>A. squarrosum</i> Boiss.	c. 21.70 (31.66 \pm 1.02) 35.0	5.0 (5.68 \pm 0.34) 6.50	Sp	2.25 (2.43 \pm 0.06) 2.50	Sp-punctate
<i>Acanthophyllum laxiflorum</i> Boiss.	25.0 (28.25 \pm 1.04) 30.0	4.5 (4.80 \pm 0.60) 5.10	Sp	4.25 (4.50 \pm 0.07) 4.75	Sp-Punctate
<i>Arenaria serpyllifolia</i> L.	20.5 (25.30 \pm 0.20) 26.5	2.5 (3.46 \pm 0.33) 4.5	Sp	2.25 (2.38 \pm 0.02) 2.5	Sp-punct
<i>Cerastium dahuricum</i> Fisch.	33.1 (37.51 \pm 0.40) 40.0	3.75 (5.22 \pm 0.14) 6.50	Sp	2.50 (2.81 \pm 0.86) 3.50	Sp-Punct
<i>C. dichotomum</i> L.	30.0 (33.48 \pm 1.02) 35.0	4.75 (5.20 \pm 0.07) 5.75	Sp	4.75 (5.20 \pm 0.07) 5.75	Sp- Punct
<i>C. glomeratum</i> Thuill	25.75 (30.29 \pm 1.38) 34.5	2.75 (3.25 \pm 0.23) 4.0	Sp	2.25 (2.33 \pm 0.05) 2.50	Sp-Punct
<i>C. pusillum</i> Ser.	31.25 (34.37 \pm 0.58) 36.25	4.0 (4.60 \pm 0.13) 5.0	Sp	2.10 (2.32 \pm 0.64) 2.50	Sp-Punct
<i>C. thomsonii</i> Hook.f.	31.25 (34.47 \pm 0.75) 37.50	4.0 (4.75 \pm 0.11) 5.0	Sp	1.75 (2.32 \pm 0.08) 2.50	Scab-punct
<i>Cerastium cerastioides</i> (L.) Britton	30.10 (34.10 \pm 0.38) 36.75	3.0 (4.30 \pm 0.14) 5.0	Sp	2.5 (3.60 \pm 0.13) 4.5	Sp-Punct
<i>Dionthus cachmericus</i> Edgew	47.50 (50.38 \pm 1.87) 56.70	5.50 (7.05 \pm 0.86) 10.0	Sp	4.10 (4.20 \pm 0.10) 4.50	Sp-Punctate

Table 3. (Cont'd.).

Taxa	Pollen diameter μm	Pore diameter μm	Operculum	Exine in μm	Tectum
<i>D. crinitus</i> Sm	40.0 (41.75 \pm 0.87) 45.0	6.25 (7.05 \pm 0.20) 7.50	Sp	2.50 (3.20 \pm 0.24) 4.01	Sp-Punctate
<i>D. jacquemontii</i> Edgew ex Hooky	37.50 (43.0 \pm 0.88) 47.50	5.0 (6.47 \pm 0.20) 7.50	Sp	3.25 (4.25 \pm 0.17) 5.0	Sp-Punctate
<i>D. ongatalatus</i> Royle ex Benth.	32.50 (35.71 \pm 0.60) 38.0	5.0 (5.29 \pm 0.10) 6.10	Sp	2.5 (2.56 \pm 0.04) 3.10	Sp-Punctate
<i>D. orientalis</i> Adams.	42.50 (43.90 \pm 0.58) 45.0	6.25 (7.05 \pm 0.24) 7.50	Sp	2.5 (3.20 \pm 0.20) 4.10	Sp-Punctate
<i>D. anatolicus</i> Boiss.	34.50 (36.50 \pm 0.44) 40.10	3.10 (5.87 \pm 0.18) 6.75	Sp	2.50 (2.60 \pm 0.04) 3.0	Sp-Punctate
<i>Gypsophila alsinoides</i> Bunge	27.5 (28.50 \pm 0.50) 31.0	3.50 (5.03 \pm 0.30) 6.50	Sp	2.50 (2.81 \pm 0.10) 3.25	Sp-Punct
<i>G. cerastioides</i> D. Don.	25.0 (27.53 \pm 0.09) 30.0	3.75 (4.52 \pm 0.10) 5.0	Sp	2.25 (2.43 \pm 0.02) 2.50	Sp-Punct
<i>G. floribunda</i> (Kar. & Kir.) Turez.	20.0 (22.41 \pm 0.33) 23.75	2.50 (3.25 \pm 0.19) 4.0	Sp	1.75 (2.22 \pm 0.87) 2.5	Sp-Punct
<i>G. muralis</i> (Klok.) Schischkin	24.5 (26.25 \pm 0.411) 27.5	2.50 (3.02 \pm 0.11) 3.50	Sp	2.10 (2.30 \pm 0.05) 2.51	Sp-Punct
<i>G. sedifolia</i> Kurz.	25.20 (27.82 \pm 0.44) 30.1	4.50 (3.20 \pm 0.14) 6.25	Sp	2.25 (2.30 \pm 0.037) 2.50	Sp-Punctate
<i>G. bellidifolia</i> Boiss.	23.75 (25.28 \pm 0.38) 27.0	2.5 (3.28 \pm 0.10) 4.25	Sp	2.25 (2.3 \pm 0.047) 2.51	Sp-Punct
<i>Holosteum umbellatum</i> L.	35.0 (40.44 \pm 0.37) 42.50	4.50 (5.05 \pm 0.047) 5.75	Sp	2.50 (3.08 \pm 0.12) 4.50	Sp-Punct
<i>Lepyrodicilis stellarioides</i> F. & M.	28.75 (35.55 \pm 0.6) 38.70	2.5 (3.15 \pm 0.093) 4.2.5	Sp	2.5 (2.99 \pm 0.116) 4.25	Sp-Punct
<i>L. tenera</i> Boiss.	30.0 (32.9 \pm 0.14) 50	4.0 (4.55 \pm 0.13) 5.0	SP	2.0 (2.82 \pm 0.13) 3.5	Sp-Punct
<i>L. holosteoides</i> (C.A. Meyer) Fenzl ex. F. & M.	27.5 (30.26 \pm 0.30) 32.5	2.75 (3.50 \pm 0.09) 3.56	Scab	2.5 (2.68 \pm 0.06) 3.25	Sp-Punct
<i>Lychnis coronaria</i> (L.) Desr.	37.50 (39.43 \pm 0.51) 42.50	3.50 (4.25 \pm 0.16) 5.70	Sp	2.75 (3.51 \pm 0.14) 4.51	Sp-Punct

Table 3. (Cont'd.).

Taxa	Pollen diameter μm	Pore diameter μm	Operculum	Exine in μm	Tectum
<i>Mimuarria biflora</i> (L.) Schinz-Thell	26.25 (27.5 \pm 0.26) 28.25	3.2.5 (4.82 \pm 0.24) 5.5	Sp	2.5 (2.83 \pm 0.12) 3.2	Sp-Punct
<i>M. hybrida</i> (Vill.) Schischkin	27.5 (28.25 \pm 0.40) 29.0	3.5 (4.0 \pm 0.28) 4.3.0	Sp	2.5 (2.83 \pm 0.16) 3.0	Sp-Punct
<i>M. kashmirica</i> (Edgew.) Mattf.	25.0 (31.46 \pm 0.57) 34.25	4.0 (4.85 \pm 0.78) 5.0	Sp	2.25 (2.48 \pm 0.02) 2.75	Scb-Punct
<i>Myosoton aquaticum</i> (L.) Moench	30.1 (32.71 \pm 0.49) 35.70	5.0 (5.49 \pm 0.20) 7.50	Sp	2.25 (2.53 \pm 0.04) 3.0	Sp-Punct
<i>Petrorhagia alpina</i> (Habl.) Ball. & Heywood	20.0 (21.17 \pm 0.28) 22.5	2.50 (3.03 \pm 0.14) 5.0	Sp	1.15 (2.214 \pm 0.10) 2.50	Sp-Punctate
<i>Pseudostellaria heterantha</i> (Maxim.) Pax	28.75 (32.93 \pm 0.45) 36.25	3.5 (4.65 \pm 0.12) 5.0	Sp	2.25 (2.43 \pm 0.02) 2.5	Sp-Punct
<i>Silene arenosa</i> C. Koch	36.0 (38.0 \pm 0.45) 43.75	5.0 (6.0 \pm 0.170) 7.5	Sp	2.5 (3.06 \pm 0.08) 3.75	Sp-Punct
<i>S. blatteri</i> Matts.f.	26.25 (29.27 \pm 0.45) 31.25	3.5 (2.65 \pm 0.10) 3.25	Sp	2.0 (3.02 \pm 0.18) 4.25	Scb-Punct
<i>S. coelirosea</i> (L.) Godron	35.10 (39.26 \pm 0.30) 4.25	6.25 (6.91 \pm 0.11) 7.52	Sp	2.5 (3.22 \pm 0.09) 4.0	Sp-Punct
<i>S. conoidea</i> L.	40.0 (45.84 \pm 0.66) 52.5	5.0 (6.2 \pm 0.160) 7.5	Sp	2.5 (3.14 \pm 0.15) 4.25	Scab-Punct
<i>Silene falconeriana</i> Benth.	35.0 (40.52 \pm 0.97) 44.25	5.50 (6.90 \pm 0.24) 7.75	Sp	3.25 (4.1 \pm 0.112) 4.5	Sp-Punct
<i>S. longisepala</i> E. Nasir	35.0 (38.58 \pm 1.58) 40.0	4.25 (4.83 \pm 0.08) 5.25	Sp	2.5 (2.93 \pm 0.13) 3.0	Scab-Punct
<i>S. moorcroffiana</i> Wall. ex Benth.	35.0 (37.58 \pm 0.70) 40.0	4.75 (5.08 \pm 0.10) 5.50	Sp	3.0 (3.50 \pm 0.11) 3.75	Scab-Punct
<i>Stellaria decumbens</i> Edgew.	25.0 (26.5 \pm 0.47) 28.75	3.0 (3.85 \pm 0.20) 47.5	Sp	2.25 (2.35 \pm 0.03) 2.50	Sp-Punct
<i>S. kotschyana</i> Fenzl ex Boiss.	27.5 (28.47 \pm 0.90) 30.0	3.50 (4.25 \pm 0.15) 5.0	Sp	2.25 (2.65 \pm 0.10) 3.25	Sp-Punct
<i>S. monosperma</i> Buch.-Ham. ex Don	27.5 (30.05 \pm 0.30) 32.5	3.75 (4.53 \pm 0.82) 50	Sp	2.5 (2.71 \pm 0.05) 3.50	Sp-Punct

Table 3. (Cont'd.).

Taxa	Pollen diameter μm	Pore diameter μm	Operculum	Exine in μm	Tectum
<i>S. nana</i> Kar. & Kir.	37.1 (38.58 \pm 0.5) 37.5	4.25 (4.83 \pm 0.08) 5.25	Sp	2.5	Sp-Punct
<i>S. persica</i> Boiss.	45.0 (5.25 \pm 0.16) 65.0	4.0 (42.5 \pm 0.48) 45.0	Sp	2.5 (3.0 \pm 0.10) 3.75	Scb-Punct
<i>S. subumbellata</i> Edgew. ex Edgew. & Hook.f.	27.5 (28.12 \pm 0.62) 30.0	3.0 (3.50 \pm 0.22) 4.0	Sp	2.0 (2.25 \pm 0.10) 2.5	Sp-Punct
<i>S. uliginosa</i> Mur.	25.0 (28.95 \pm 0.65) 29.5	2.50 (2.95 \pm 11.0) 3.25	Sp	2.25 (2.45 \pm 0.07) 2.75	Sp
<i>S. viscosa</i> (L.) Pers.	c. 45	6.50 (6.60 \pm 0.12) 6.70	Sp	c. 4.25	Sp-Punct
<i>S. vulgaris</i> (Moench) Garcke	42.50 (46.10 \pm 0.75) 54.50	6.25 (7.50 \pm 0.16) 8.75	Sp	2.75 (3.40 \pm 0.11) 40.0	Sp-Punct
<i>Sagina saginoides</i> (L.) Karst.	25.0 (26.83 \pm 0.60) 28.50	2.50 (2.95 \pm 0.11) 3.25	Sp	2.25 (2.29 \pm 0.04) 2.50	Sp-Punct
<i>Saponaria subrosularis</i> Rech.f.	35.0 (41.85 \pm 0.41) 43.75	5.25 (6.83 \pm 0.18) 7.50	Sp	2.5 (2.65 \pm 0.05) 3.25	Sp
<i>Silene citrina</i> Boiss.	37.50 (40.2 \pm 0.68) 42.50	6.5 (7.20 \pm 0.18) 7.50	Sp	2.50 (2.87 \pm 0.10) 3.26	Sp-Punct
<i>Silene kanavarensis</i> Benth.	37.50 (42.50 \pm 0.70) 45.0	5.25 (6.37 \pm 0.22) 7.50	Sp	4.25 (4.50 \pm 0.05) 4.75	Scab-punct
<i>Silene tenuis</i> Willd.	32.5 (34.81 \pm 0.20) 37.5	6.75	Sp	2.50 (2.88 \pm 0.09) 3.75	Sp-Punct
<i>Stellaria media</i> (L.) Vill.	25.25 (30.36 \pm 0.80) 33.25	3.0 (3.80 \pm 0.14) 5.0	Sp	2.0 (2.65 \pm 0.11) 3.25	Sp-Punct
<i>Vaccaria hispanica</i> (Miller) Rauschert	35.50 (38.87 \pm 0.43) 40.0	5.0 (6.025 \pm 0.26) 7.0	Sp	2.50 (2.75 \pm 0.08) 3.25	Sp-punctate
<i>Velesia rigida</i> L.	32.5 (33.95 \pm 0.45) 38.25	3.75 (4.50 \pm 0.04) 2.50	Sp	2.0 (2.3 \pm 0.04) 25.0	Punctate-Sp

Fig. 1. Scanning micrographs: *Silene indica*: A, Pollen grain; B, Exine pattern. *Cucubalus baccifer*: C, Pollen grain; D, Exine pattern. *Gypsophila cerastioides*: E, Pollen grain, F, Exine pattern.

Pollen type: *Spergula arvensis*-type - (Fig. 2 A-F)**Pollen class:** Tricolpate, 4-10 colpate.**P/E ratio:** 0.85-1.73**Shape:** Prolate-spheroidal-sub-prolate or prolate rarely spheroidal Apertures: Colpus long sunken with acute ends.**Exine:** sexine thicker or thinner than or as thick as nexine.**Ornamentation:** Scabrate-punctate or spinulose-punctate.**Measurements:** Size: Polar axis P = 21 (32 ± 1.2) 44, and equatorial diameter E = 19 (28 ± 2.1) 37 µm. Colpi 16.61 (34 ± 1.4) 25 µm long. Exine 0.9-2.5 µm thick, sexine as thick as nexine. Tectum scabrate-punctate.**Species included:** *Spergula fallax* (Lowe) E.H.L. Kraus., *S. arvensis* L., *Spergularia media* (L.) Presl., *S. diandra* (Guss) Heldr. Sart, *Spergula marina* (L.) Griseb., *Polycarpha carymbosa* (L.) Lam., *P. spicata* Wight & Arn., *Telephium imperati* L.**Key to the species**

- 1 + Pollen grains 14-18 µm in polar length
 Group-I (*Polycarpha carymbosa*, *P. spicata*)
 - Pollen grains more than 18 µm in polar length 2
- 2 + Pollen grains prolate or sub-prolate 3
 - Pollen grains prolate-spheroidal or spheroidal 4
- 3 + Pollen grains subprolate *Spergula fallax*
 - Pollen grains prolate *Telephium imperati*
- 4 + Pollen grains spheroidal *S. diandra*
 - Pollen grains prolate-spheroidal 5
- 5 + Pollen grains 3-colpate *Spergularia media*
 - Pollen grains 3-10 colpate.....Group-II (*Spergula arvensis*, *Spergularia marina*)

Pollen type: *Stellaria media*- type (Fig. 1E & F; Figs. 3 and 4A-F)**Pollen class:** Pantoporate**P/E ratio:** 1.00**Shape:** Spheroidal**Apertures:** Pore more or less circular, operculate, annulate, or non-operculate.**Exine:** Sexine thicker than nexine.**Ornamentation:** Spinulose punctate or scabrate-punctate.**Measurements:** Size: Length = (32.5-) 37.12 ± 0.78 (-37.5) µm and Breadth (35.1) 37 ± 0.82 (40) µm, pore (7.5-) 10.11 ± 0.42 (12.5) µm in diameter. Exine 2.5 µm thick, sexine thicker than nexine. Tectum Spinulose-punctate**Species included:** *Acanthophyllum laxiflorum* Boiss, *A. squarrosum* Boiss., *A. sordidum* Bunge ex Boiss., *Arenaria serpyllifolia* L., *A. leptoclados* (Reichb.) Guss., *Arenaria neelgherrensis* Wight & Arn., *A. orbiculata* Royle ex Edgew., *A. giiffithii* Boiss., *Cerastium cerastioides* (L.) Britton, *C. dichotomum* L., *C. glomeratum* Thuill, *C. thomsoni* Hook.f., *C. dahuricum* Fisch., *C. pusillum* Ser., *Dianthus anatolicus* Boiss, *D. crinitus* Sm, *D.orientalis* Adams., *D. angulatus* Royle ex Benth., *D. cachmericus* Edgew.,

Fig. 2. Scanning micrographs: *Spergula fallax*: A, Polar view; B, Exine pattern. *Spergularia diandra*: C, Polar view; D, Exine pattern. *S. media*: E, Equatorial view; F, Polar view. Scale bar = A, B, D & F = 10; A, C = 1 μm .

Fig. 3. Scanning micrographs: *Arenaria neelgherrensis*: A, Pollen grains; B, Exine pattern. *Minuartia biflora*: C, Pollen grain. *Minuartia hybrida*: D, Exine pattern. *Lepyrodiclis tenera*: E, Pollen grain. *L. stellarioides*: F, Exine pattern.
Scale bar = A-F = 10 μ m.

Fig. 4. Scanning micrographs: *Stellaria uliginosa*: A, Pollen grains; B, Exine pattern. *Stellaria blatteri*: C, Pollen grain. D, Exine pattern. *Holosteum umbellatum*: E, Pollen grain; F, Exine pattern.
Scale bar = A-F = 10 μ m.

D. jacquemontii Edgew ex Hook.f., *Gypsophila bellidifolia* Boiss., *G. floribunda* (Kar. & Kir.) Turcz., *G. muralis* (Klok.) Schischkin, *G. cerastioides* D. Don, *G. alsinoides* Bunge, *G. sedifolia* Kurz., *Holosteum umbellatum* L., *Lepyrodiclis holosteoides* (C.A. Meyer) Fenzl ex. F. & M., *Lychnis coronaria* (L.) Desr., *Lepyrodiclis stellarioides* F. & M., *L. tenera* Boiss., *Minuartia kashmirica* (Edgew.) Mattf., *M. hybrida* (Vill.) Schischkin, *M. biflora* (L.) Schinz-Thell, *Myosoton aquaticum* (L.) Moench, *Petrorhagia alpina* (Habl.) Ball & Heywood, *Pseudostellaria heterantha* (Maxim.) Pax, *Sagina saginoides* (L.) Karst., *Saponaria subrosularis* Rech.f., *Silene kunawarensis* Benth., *S. viscosa* (L.) Pers., *Silene tenuis* Willd., *S. falconeriana* Benth., *Silene citrina* Boiss., *S. vulgaris* (Moench) Garcke, *S. moorcroftiana* Wall. ex Benth., *S. longisepala*, *S. nana* Kar. & Kir., *S. arenosa* C. Koch, *S. conoidea* L., *S. coelirosea* (L.) Godron, *Stellaria media* (L.) Vill., *S. monosperma* Buch.–Ham. ex Don, *S. decumbens* Edgew., *S. persica* Boiss., *S. subumbellata* Edgew. ex Edgew & Hook.f., *S. uliginosa* Mur., *S. kotschyana* Fenzl ex Boiss, *S. blatteri* Mattf., *Vaccaria hispanica* (Miller) Rauchert and *Velezia rigida* L.

Key to the species and species group

- + Pollen grains spinulose-punctate Group-I
Acanthophyllum laxiflorum Boiss, *A. squarrosum* Boiss., *A. sordidum* Bunge ex Boiss., *Arenaria serpyllifolia* L., *A. leptoclados* (Reichb.) Guss., *Arenaria neelgherrensis* Wight & Arn., *A. orbiculata* Royle ex Edgew., *A. giiffithii* Boiss., *Cerastiumcerastioides* (L.) Britton, *C. dichotomum* L., *C. glomeratum* Thuill, *C. dahuricum* Fisch., *C. pusillum* Ser., *Dianthus anatolicus* Boiss, *D. crinitus* Sm, *D. orientalis* Adams., *D.angulatus* Royle ex Benth., *D. cachmericus* Edgew, *D. jacquemontii* Edgew ex Hook.f., *Gypsophila bellidifolia* Boiss., *G. floribunda* (Kar. & Kir.) Turcz, *G. muralis* (Klok.) Schischkin, *G. cerastioides* D. Don, *G. alsinoides* Bunge, *G. sedifolia* Kurz., *Holosteum umbellatum* L., *Lepyrodiclis holosteoides* (C.A. Meyer) Fenzl ex. F. & M., *Lychnis coronaria* (L.) Desr., *Lepyrodiclis stellarioides* F. & M., *L. tenera* Boiss., *Minuartia kashmirica* (Edgew.) Mattf. *Minuartia hybrida* (Vill.) Schischkin, *M. biflora* (L.) Schinz-Thell *Myosoton aquaticum* (L.) Moench, *Petrorhagia alpina* (Habl.) Ball & Heywood, *Pseudostellaria heterantha* (Maxim.) Pax *Sagina saginoides* (L.) Karst., *Saponaria subrosularis* Rech.f., *S. viscosa* (L.) Pers., *Silene tenuis* Willd., *S. falconeriana* Benth, *Silene citrina* Boiss. *S. vulgaris* (Moench) Garcke, *S. arenosa* C. Koch, *S. conoidea* L., *S. coelirosea* (L.) Godron, *Stellaria media* (L.) Vill., *S. monosperma* Buch.–Ham. ex Don, *S. decumbens* Edgew., *S. persica* Boiss., *S. subumbellata* Edgew. ex Edgew & Hook.f., *S. uliginosa* Mur., *S. kotschyana* Fenzl ex Boiss, *Velezia rigida* L.
- Pollen grains scabrate- punctate Group-II
Stellaria blatteri Matts, *Cerastium thomsonii* Hook.f., *Silene kunawarensis* Benth., *S. moorcroftiana* Wall.ex Benth., *S. longisepala*, *S. nana* Kar. & Kir., *S. conoidea* L.

Discussion

Caryophyllaceae is a stenopalynous family. Pollen grains are usually radially symmetrical, apolar rarely isopolar, pantoporate rarely 3-10 colpate, spheroidal or prolate-spheroidal-sub-prolate to rarely prolate. Tectum spinulose-punctate or scabrate-punctate often reticulate-reticulate to scabrate. However, considerable variation in

apertural types and exine pattern has been observed. On the basis these characters three distinct pollen types are recognized viz., pollen type-I: *Silene indica* is recognized by having porate pollen with reticulate or reticulate-scabrate tectum. It comprises of 4 species (see key to the species). Pollen type-II: *Spergula arvensis* is characterized by colpate pollen with spinulose-punctate or scabrate-punctate tectum 8 species are included in this pollen type. Pollen type-III: *Stellaria media* is easily delimited by having porate pollen with spinulose-punctate tectum, 61 species are present in this type. Although, the species belonging to this pollen type are fairly uniform in different pollen characters but on the basis of tectum species of this types can be divided into two subtypes (see Account of pollen types).

In the family Caryophyllaceae majority of the genera viz., *Acanthophyllum*, *Arenaria*, *Dianthus*, *Cerastium*, *Gypsophila*, *Holosteum*, *Lepyrodiclis*, *Lychnis*, *Minuartia*, *Myosoton*, *Petrorhagia*, *Pseudostellaria*, *Stellaria*, *Sagina*, *Silene*, *Saponaria*, *Vaccaria* and *Velezia* are fairly uniform by having pantoporate grains, with spinulose-scabrate/ punctate tectum. However, in 3 species of *Silene* i.e. *S. brahuica*, *S. gonosperma* (Rupr.) Bocquet and *S. indica* Roxb. ex Otth and the genus *Cucubalus* reticulate tectum is present. Nowicke (1976) and Nowicke & Skvarla (1979) also reported similar type of pollen from these species.

In contrast to this in *Spergularia*, *Spergula*, *Polycarpaea* and *Telephium* 3-10-colpate grains are found. However, in the genus *Telephium* along colpate grains 3-colporate grains are also found. Erdtman (1952) reported only 3 - colpate pollen grains in the same species. In the genus *Polycarpaea* and in 2 species of *Spergularia* i.e. *S. media* (L.) Presl and *S. diandra* (Guss.) Heldr. & Sart., only tricolpate grains are found, while in the genus *Spergula* and a single species of *Spergularia* (*S. marina* (L.) Griseb.) pantocolpate grains occur.

Shape of the grain also varies from spheroidal to prolate-spheroidal mostly spheroidal, Kubitzki (1990) divided the family into three subfamilies viz., Paronychioideae, Alsinoideae and Caryophylloideae on the basis of floral characters and presence and absence of stipules. With few exceptions, the three pollen types recognized on the basis of apertural types and exine ornamentation correspond with the subfamilial classification of the family Caryophyllaceae. For instance, in the pollen type *Silene indica* species of subfamily Paronychioideae are found. However, the Pollen type *Stellaria media* occur in both the subfamilies i.e., Alsinoideae and Caryophylloideae. Palynologically family Caryophyllaceae is more or less similar to Illeceberaceae both have porate rarely colpate pollen spinulose-punctate tectum (Perveen & Qaiser, 2003).

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